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Evaluation of Nickel Titanium Instruments on Apical Debris Extrusion in Curved Canals

Farklı Nikel Titanyum Eğelerin Eğimli Kanallarda Apikal Debris Taşkınlıklarının Değerlendirilmesi

ABSTRACT

Objectives: This study evaluated the amount of debris extrusion after instrumentation with various instruments in curved root canals

Materials and Method: Curved mesial roots of mandibular first molar teeth were instrumented using XP-endo Shaper, HyFlex, ProTaper Next, TF-Adaptive, and 2Shape instruments. All procedures were performed at 35°C. The extruded debris was collected into pre-weighed Eppendorf tubes. The tubes were weighed to obtain the weight of the debris. The weight of debris was calculated by subtracting the initial weight of the tube from the final weight.

Results: All of the instruments were associated with apical debris extrusion. No significant difference was found between the groups. 2Shape instruments demonstrated the highest mean extrusion value, whereas TF-Adaptive instruments demonstrated the lowest (p>0.05).

Conclusion: None of the instrument systems or instrumentation kinematics significantly reduced the amount of apical debris extrusion in curved roor canals.

Key words: Apical Debris Extrusion, Adaptive Motion, Controlled Memory, Curved Canal, Nickel Titanium Instrument

ÖZ

Amaç: Bu çalışmada farklı eğelerin, eğimli kanallarda enstrümantasyon sonrasında oluşturdukları debris taşkınlığı miktarları incelenmiştir.

Gereç ve Yöntemler: Alt çene birinci büyük azı dişlerinin eğimli mezial kökleri XP-endo Shaper, HyFlex, ProTaper Next, TF-Adaptive ve 2Shape kullanılarak şekillendirildi. Tüm işlemler 35°C'de uygulandı. Taşan debris miktarı önceden ağırlıkları ölçülmüş olan Ependorf tüplerinde toplandı. Tüpler debris ağırlığının elde edilmesi için işlem sonrasında tekrar ölçüldü. Taşan debris miktarı boş tüpün ağırlığının işlem sonrası debris içeren tüp ağırlığından çıkarılması ile hesaplandı.

Bulgular: Tüm eğeler apikal debris taşkınlığına neden oldu. Gruplar arasında anlamlı fark bulunmadı. 2Shape eğeleri en yüksek ortalama debris taşkınlığı gösterirken, TF-Adaptive eğeler en düşük değerleri gösterdi (p>0,05).

Sonuç: Eğe sistemleri veya enstrümantasyon kinematiklerinin eğimli kanallarda apikal debris taşkınlığını anlamlı olarak azaltmadığı tespit edildi.

Anahtar Kelimeler: Apikal Debris Taşkınlığı, Adaptif Hareket, Kontrol Memory, Eğimli Kanal, Nikel Titanyum Eğe

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INTRODUCTION

The irrigation solutions, tissue remnants, and microorganisms may extrude during the instrumentation root canals into the periapical tissue via apical foramen (1). The postoperative pain was associated with extruded materials, which may cause swelling and flare-ups (2). The amount of debris extrusion may vary depending on the instrument and instrumentation technique used (3).

XP-endo Shaper (XPS; FKG Dentaire, La Chaux-De-Fonds, Switzerland) was fabricated from a special nickel titanium (NiTi) alloy named Max-wire. The XPS file, with a tip size of ISO 30, achieves a maximum 0.4 taper size, when exposed to 35°C. The instrument transforms to austenitic phase from the martensitic phase at body temperature due to the thermal process on the MaxWire (4). The MaxWire takes a predetermined curved shape when it reaches a temperature of 35ºC which is close to the body temperature within the root canal (5). The pre-determined snake shape and flexibility of the file provide an effective preparation at the body temperature, especially for the curved canals which are difficult to clean with conventional NiTi file systems (6).

A unique thermal process provides a controllable memory for the HyFlex Controlled Memory (HCM; Coltene-Whaledent, Altstätten, Switzerland) system (7). The CM wire is produced by thermal procedures for changing the austenite/martensite phases of the NiTi alloy. The difference in alloy and file design provide HCM system a greater flexibility, as well as superior ability for maintaining the original canal curvature safely (8).

The ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) system consists of M-wire manufactured instruments with variable taper design. The design of instruments provides an asymmetric rotary motion which decreases the screwing effect, and reduces apical debris extrusion (9,10). M-wire alloy provides more flexible and resistant characteristics of the instruments (8). The taper design and cross section of instruments may lead higher amount of debris removal to the coronal direction (10).

TF-Adaptive (TFA, SybronEndo, Orange, CA, America) system uses a combination of rotation and reciprocation movements. The TFA file has three design properties: surface conditioning, R-phase heat treatment, and twisting of the metal (11). These properties minimize clinical complications such as transportation, even in severely curved root canals (12). The files work in 6000 clockwise rotation and when a resistance occurs 3700 clockwise with 500 counter clockwise rotation, automatically. This adaptive motion allows better cutting efficiency and minimized apical extrusion (13).

The 2Shape (2S; Micro Mega, Besancon, France) system is a new generation NiTi file system used in rotation motion. The instrument has an asymmetric design consisting of 2 active cutting edges and 1 non-active cutting edge. 2S is made of a T-Wire thermal treatment technology that demonstrates higher flexibility and fracture resistance compared with traditional NiTi instruments (14).

This study compared the amount of apical debris extrusion in curved root canals after instrumentation with different instruments.

MATERIAL AND METHODS

Ethics committee approval was obtained (protocol number 2017-76-09/08) from Clinical Research Ethics Committee. 120 extracted human mandibular first molar teeth with curved mesial type of Vertucci IV canals were included. All remnants on the external root surface were removed. The root canals with immature apices, any sign of cracks, calcified root canals, or having a previous root canal treatment were excluded.

The crowns were flattened, 19 mm length was obtained, then the roots were sectioned in buccolingual direction. The mesial roots were used for the experimental setup. The canal patency of mesiobuccal canal was controlled with size 10 K-file inserted into the canal until the tip was visible. The length of file was accepted as the real length, and the working length was calculated by subtracting 1 mm. The specimen having apical diameter larger than size 15 K-file was excluded. The digital periapical radiographs were obtained using sensor and X-ray device (MyRay, Imola, Italy) with a 0.4 s exposure time at a distance of 10 cm. The canal curvature and the radius were calculated with the methodology described by Schneider (15) and Schäfer et al (16). Teeth having curvature between 20-40° and curvature radius ≤ 12 mm were selected.

The extruded debris was accumulated into Eppendorf tubes (17). The experimental design consisted of an Eppendorf tube without its cover inserted into a glass vial. The initial weight of the tube was weighed after removal of the cover, using an analytical balance (Radwag, Radom, Poland) with 10-4 accuracy. The weighing was repeated three times and averaged. The experimental setup was prepared as follows; the cover of the tube was removed, a hole to fit the root was created, the mesial root as the specimen, a 27-gauge needle to equalize the air pressure inserted through the hole. The root and the needle were fixed to the cover with cyanoacrylate to create a unit design. Then, the unit was attached to the Eppendorf tube which was fitted into an aluminium coated vial. All treatment procedures were completed by a single operator to avoid any variation and eliminate bias. The units were divided into equal groups randomly (N = 24), as follows:

Group 1: A torque-controlled endodontic motor (X-Smart, Dentsply-Maillefer, Konstanz, Switzerland) was used at a rotational speed of 800 rpm and a torque rotation of 100 gcm. The XP-endo Shaper file size 30/.04 was advanced in the root canal with slightly forward and backward motion, and was attempting to reach a working length with 3 to 5 movements.

Group 2: HCM files were used at 500 rpm rotational speed and 250 gcm torque settings with endodontic motor. The files were used gently with the in-and-out motion. The sequence of files was; size 25/.08 (two-thirds of the working length), size 20/.06, and size 25/.06 taper (the full working length).

Group 3: PTN files were used in the sequence of SX (19/.04), PTN X1 (17/.04), and PTN X2 (#25/.06) at 300 rpm rotational speed and 200 gcm torque, with the same endodontic motor. The coronal third was prepared with SX file. The instrumentation was performed with a gentle brushing outstroke motion until X2 file reached the working length.

Group 4: In the TFA group, the canal preparation was completed with the SM1 (20/.04) and SM2 (25/.06) files up to the working length. The Elements motor (SybronEndo, Orange, CA, USA) was used with adaptive motion at a 500 rpm speed and 400 gcm torque.

Group 5: In 2S group, the working length was reached with 2S1 (25/.04) file and preparation was completed with 2S2 (25/.06) file. The endodontic motor was used at a speed of 300 rpm and a torque of 120 gcm. No apical directional force was applied to the instrument in the canal.

All procedures were performed at 35 °C inside a cabinet. A total of 10 ml distilled water was used for each canal. The accumulated debris on the instrument was cleaned during instrumentation. A single instrument was used for each specimen and discarded. The occurrence of any file breakage was recorded and the specimen was excluded, and a new specimen was included.

The unit, including the cover and the root, was removed when the instrumentation was completed. The root surface was irrigated with 1 ml of distilled water to collect the remaining debris. The tubes, including the debris were stored in an incubator at 68°C for 5 days to obtain a dry debris before weighing. The same analytical balance was used to weigh the final amount of debris. The tubes were weighed for three times and averaged. The amount of debris extrusion was calculated by subtracting the initial weight from the final weight.

Statistical analysis was performed with SPSS 19.0 software (SPSS Inc., Chicago, IL, USA). Normal distribution of the weights was verified using the Shapiro-Wilk test. Kruskal-Wallis non-parametric test was used to compare the data that did not conform to normal distribution. Since no statistically significant difference was found, the statistical comparisons were not performed. The medians with interval values were calculated for each parameter according to the statistical unit. A P-value of < 0.05 was considered statistically significant for all tests.

RESULTS

All instrumentation systems caused apical debris extrusion. No significant difference was found between the groups ($p>0.05$). Group 5 (2S) demonstrated the highest mean extrusion value, whereas group 4 (TFA) demonstrated the lowest ($p>0.05$). The mean values and standard deviations (SD) of debris extrusion for all groups are listed in Table 1.

Debris extrusion	XPS	HCM	PTN	TFA	TS
Mean	0.001333	0.001216	0.001316	0.001116	0.001533
SD	0.0005158	0.0004797	0.0005180	0.0004832	0.0007686

Table 1: Mean weights of debris (g)

The mean angle value of the roots was determined as 30.5˚. The relationship between the amount of debris and angles was statistically analyzed. However, no significant difference was found between the degree of angle and the amount of debris extrusion ($p>.05$). The average angles are listed in Table 2.

Group	XPS	HCM	PTN	TFA	TS
Angle	30.68	30.22	30.71	30.70	30.23

Table 2: Average angles (°)

DISCUSSION

Postoperative pain after root canal treatment may reduce by elimination of debris extrusion (10). The tooth type may influence the amount of extruded debris. Posterior teeth demonstrate significantly higher incidence of postoperative pain (18). In this study, the curved mesiobuccal canals of mandibular first molar teeth were used to compare the amount of extruded debris using a commonly accepted methodology (10). The methodology provides a standardized comparison with a limitation of mimicking the periapical tissues (19). All irrigation procedures were completed with distilled water to prevent the incorrect measurement due to the crystallization of sodium hypochlorite.

Several studies evaluated the effect of the canal curvature on the amount of debris extrusion. In order to determine the root canal curvature, Hinrichs et al. (20) used Schneider's method (15) and Leonardi et al. (21) classified the moderately or slightly curved root canal groups. In our study, the mesiobuccal canals of mandibular molar teeth were determined using the ImageJ program, according to the methods of Schneider and Schäfer et al. (15,16). The root canals varying between 20º-40º and demonstrating a radius of curvature of equal to 12 mm or < 12 mm were included. Schneider (15) defined root angles as moderate curved up to 25º and angles greater than 25º as severely curved. According to this classification, our study evaluated moderately and severely curved canals, although an average root angle of 30.5o was obtained.

The influence of canal anatomy on the debris extrusion is unclear. No correlation was reported between the canal curvature and the amount of extruded debris (20,21). Karataşlıoğlu et al. (22) reported that there was no significant difference between moderate and severe curvatures of canals in terms of apical debris extrusion, albeit a significant between slightly curved and severely curved canals. This finding was related to a possible less movement of debris to the coronal direction in the curved parts of the root canals. Our results supported these findings since there was no significant difference between the curvature degree of root canals when the canals have moderate and severely curvatures.

The present study compared files having different designs, production methods, number of files, and kinematics. The instrumentation technique and the individual design of the instruments effect the debris extrusion (23). Çapar et al. (23) reported that PTN and TFA systems caused less debris extrusion than HCM in straight canals. However, no difference was reported between PTN and TFA systems. On the contrary, unlike the results in straight canals, the HCM files caused less amount of debris extrusion than the PTN files in root canals having curvature more than 20º (1). The fact that HCM caused less debris extrusion was explained by the physical properties of instruments. Our results were comparable Çapar et al. (23), and the TFA system resulted in a less amount of apical debris than the HCM without any significant difference. On the other hand, the TFA file caused in a less amount of apical debris in the curved canals than the PTN file. A similar result was obtained in curved canals without any significant difference, and HCM caused a less amount of debris extrusion than PTN (1). The TFA system did not demonstrate a significant difference from the PTN and HCM systems in curved canals, but caused less debris extrusion. This finding may be related to the fact that the TFA system, which uses a motion similar to a continuous rotation, continues to work with a reciprocation-like motion when encountered with resistance. We may conclude that adaptive movement of the file causes less flood debris in the high degree of curvatures. The HCM system caused less debris extrusion than other rotary file systems, which may be related to the fact that saving the original shape of the root canal is crucial in curved canals for debris extrusion. As the HCM system can be used with an inclination due to shape memory in curved canals, it can protect the original shape of the canal with its super elastic feature.

The size of final instrument may affect the amount of apical debris extrusion (9). In this study, four systems had tip diameters equivalent to size 25/.06, whereas the XPS converts to approximately 30/.04. XPS and HCM caused a similar amount of debris extrusion without any significance. Based on this finding, the amount of debris extrusion is a multifactorial situation and the effect of instrument size may be conflicting.

CONCLUSION

In conclusion, all instrumentation systems caused debris extrusion. Adaptive motion may be a good option for instrumentation of severely curved to reduce debris extrusion.

DECLARATION OF CONFLICTING INTERESTS

The Authors declare that there is no conflict of interest.

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